ASME BPVC.IV-2025

SECTION IV

2025 ASME Boiler and Pressure Vessel Code

An International Code

Rules for Construction of Heating Boilers

ASME
SETTING THE STANDARD

AN INTERNATIONAL CODE

2025 ASME Boiler & Pressure Vessel Code

2025 Edition July 1, 2025

IV

RULES FOR CONSTRUCTION OF HEATING BOILERS

ASME Boiler and Pressure Vessel Committee
on Heating Boilers

The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: July 1, 2025

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Library of Congress Catalog Card Number: 56-3934

Adopted by the Council of The American Society of Mechanical Engineers, 1914; latest edition 2025.

The American Society of Mechanical Engineers
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FOREWORD*

In 1911, The American Society of Mechanical Engineers established the Boiler and Pressure Vessel Committee to formulate standard rules for the construction of steam boilers and other pressure vessels. In 2009, the Boiler and Pressure Vessel Committee was superseded by the following committees:

(a) Committee on Power Boilers (I)
(b) Committee on Materials (II)
(c) Committee on Construction of Nuclear Facility Components (III)
(d) Committee on Heating Boilers (IV)
(e) Committee on Nondestructive Examination (V)
(f) Committee on Pressure Vessels (VIII)
(g) Committee on Welding, Brazing, and Fusing (IX)
(h) Committee on Fiber-Reinforced Plastic Pressure Vessels (X)
(i) Committee on Nuclear Inservice Inspection (XI)
(j) Committee on Transport Tanks (XII)
(k) Committee on Overpressure Protection (XIII)
(l) Technical Oversight Management Committee (TOMC)

Where reference is made to "the Committee" in this Foreword, each of these committees is included individually and collectively.

The Committee's function is to establish rules of safety relating to pressure integrity. The rules govern the construction** of boilers, pressure vessels, transport tanks, and nuclear components, and the inservice inspection of nuclear components and transport tanks. For nuclear items other than pressure-retaining components, the Committee also establishes rules of safety related to structural integrity. The Committee also interprets these rules when questions arise regarding their intent. The technical consistency of the Sections of the Code and coordination of standards development activities of the Committees is supported and guided by the Technical Oversight Management Committee. The Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks, or nuclear components, or the inservice inspection of nuclear components or transport tanks. Users of the Code should refer to the pertinent codes, standards, laws, regulations, or other relevant documents for safety issues other than those relating to pressure integrity and, for nuclear items other than pressure-retaining components, structural integrity. Except for Sections XI and XII, and with a few other exceptions, the rules do not, of practical necessity, reflect the likelihood and consequences of deterioration in service related to specific service fluids or external operating environments. In formulating the rules, the Committee considers the needs of users, manufacturers, and inspectors of components addressed by the Code. The objective of the rules is to afford reasonably certain protection of life and property, and to provide a margin for deterioration in service to give a reasonably long, safe period of usefulness. Advancements in design and materials and evidence of experience have been recognized.

The Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction activities and inservice inspection and testing activities. The Code does not address all aspects of these activities and those aspects that are not specifically addressed should not be considered prohibited. The Code is not a handbook and cannot replace education, experience, and the use of engineering judgment. The phrase *engineering judgment* refers to technical judgments made by knowledgeable engineers experienced in the application of the Code. Engineering judgments must be consistent with Code philosophy, and such judgments must never be used to overrule mandatory requirements or specific prohibitions of the Code.

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code neither requires nor prohibits the use of computers for the design or analysis of components constructed to the requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they are

* The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Code.

** *Construction*, as used in this Foreword, is an all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection.

responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

The rules established by the Committee are not to be interpreted as approving, recommending, or endorsing any proprietary or specific design, or as limiting in any way the manufacturer's freedom to choose any method of design or any form of construction that conforms to the Code rules.

The Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code cases, and requests for interpretations. Only the Committee has the authority to provide official interpretations of the Code. Requests for revisions, new rules, Code cases, or interpretations shall be addressed to the staff secretary in writing and shall give full particulars in order to receive consideration and action (see the Correspondence With the Committee page). Proposed revisions to the Code resulting from inquiries will be presented to the Committee for appropriate action. The action of the Committee becomes effective only after confirmation by ballot of the Committee and approval by ASME. Proposed revisions to the Code approved by the Committee are submitted to the American National Standards Institute (ANSI) and published at http://go.asme.org/BPVCPublicReview to invite comments from all interested persons. After public review and final approval by ASME, revisions are published at regular intervals in Editions of the Code.

The Committee does not rule on whether a component shall or shall not be constructed to the provisions of the Code. The scope of each Section has been established to identify the components and parameters considered by the Committee in formulating the Code rules.

Questions or issues regarding compliance of a specific component with the Code rules are to be directed to the ASME Certificate Holder (Manufacturer). Inquiries concerning the interpretation of the Code are to be directed to the Committee. ASME is to be notified should questions arise concerning improper use of the ASME Single Certification Mark.

When required by context in the Code, the singular shall be interpreted as the plural, and vice versa.

The words "shall," "should," and "may" are used in the Code as follows:

- *Shall* is used to denote a requirement.
- *Should* is used to denote a recommendation.
- *May* is used to denote permission, neither a requirement nor a recommendation.

STATEMENT OF POLICY ON THE USE OF THE ASME SINGLE CERTIFICATION MARK AND CODE AUTHORIZATION IN ADVERTISING

ASME has established procedures to authorize qualified organizations to perform various activities in accordance with the requirements of the ASME Boiler and Pressure Vessel Code. It is the aim of the Society to provide recognition of organizations so authorized. An organization holding authorization to perform various activities in accordance with the requirements of the Code may state this capability in its advertising literature.

Organizations that are authorized to use the ASME Single Certification Mark for marking items or constructions that have been constructed and inspected in compliance with the ASME Boiler and Pressure Vessel Code are issued Certificates of Authorization. It is the aim of the Society to maintain the standing of the ASME Single Certification Mark for the benefit of the users, the enforcement jurisdictions, and the holders of the ASME Single Certification Mark who comply with all requirements.

Based on these objectives, the following policy has been established on the usage in advertising of facsimiles of the ASME Single Certification Mark, Certificates of Authorization, and reference to Code construction. The American Society of Mechanical Engineers does not "approve," "certify," "rate," or "endorse" any item, construction, or activity and there shall be no statements or implications that might so indicate. An organization holding the ASME Single Certification Mark and/or a Certificate of Authorization may state in advertising literature that items, constructions, or activities "are built (produced or performed) or activities conducted in accordance with the requirements of the ASME Boiler and Pressure Vessel Code," or "meet the requirements of the ASME Boiler and Pressure Vessel Code." An ASME corporate logo shall not be used by any organization other than ASME.

The ASME Single Certification Mark shall be used only for stamping and nameplates as specifically provided in the Code. However, facsimiles may be used for the purpose of fostering the use of such construction. Such usage may be by an association or a society, or by a holder of the ASME Single Certification Mark who may also use the facsimile in advertising to show that clearly specified items will carry the ASME Single Certification Mark.

STATEMENT OF POLICY ON THE USE OF ASME MARKING TO IDENTIFY MANUFACTURED ITEMS

The ASME Boiler and Pressure Vessel Code provides rules for the construction of boilers, pressure vessels, and nuclear components. This includes requirements for materials, design, fabrication, examination, inspection, and stamping. Items constructed in accordance with all of the applicable rules of the Code are identified with the ASME Single Certification Mark described in the governing Section of the Code.

Markings such as "ASME," "ASME Standard," or any other marking including "ASME" or the ASME Single Certification Mark shall not be used on any item that is not constructed in accordance with all of the applicable requirements of the Code.

Items shall not be described on ASME Data Report Forms nor on similar forms referring to ASME that tend to imply that all Code requirements have been met when, in fact, they have not been. Data Report Forms covering items not fully complying with ASME requirements should not refer to ASME or they should clearly identify all exceptions to the ASME requirements.

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ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Section of the ASME Boiler and Pressure Vessel Code (BPVC) should be sent to the staff secretary noted on the Section's committee web page, accessible at https://go.asme.org/CSCommittees.

NOTE: See ASME BPVC Section II, Part D for guidelines on requesting approval of new materials. See Section II, Part C for guidelines on requesting approval of new welding and brazing materials ("consumables").

Revisions and Errata

The committee processes revisions to this Code on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Code. Approved revisions will be published in the next edition of the Code.

In addition, the committee may post errata and Special Notices at http://go.asme.org/BPVCerrata. Errata and Special Notices become effective on the date posted. Users can register on the committee web page to receive email notifications of posted errata and Special Notices.

This Code is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number, the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Code

(4) to permit use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Code.

(c) The committee will consider proposed cases concerning the following topics only:

(1) equipment to be marked with the ASME Single Certification Mark, or

(2) equipment to be constructed as a repair/replacement activity under the requirements of Section XI

(d) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Code Section and the paragraph, figure, or table number to which the proposed case applies

(4) the editions of the Code to which the proposed case applies

(e) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Cases that have been approved will appear in the next edition or supplement of the Code Cases books, "Boilers and Pressure Vessels" or "Nuclear Components." Each Code Cases book is updated with seven Supplements.

Supplements will be sent or made available automatically to the purchasers of the Code Cases books until the next edition of the Code. Annulments of Code Cases become effective six months after the first announcement of the annulment in a Code Case Supplement or Edition of the appropriate Code Case book. The status of any case is available at http://go.asme.org/BPVCCDatabase. An index of the complete list of Boiler and Pressure Vessel Code Cases and Nuclear Code Cases is available at http://go.asme.org/BPVCC.

Interpretations

(a) Interpretations clarify existing Code requirements and are written as a question and reply. Interpretations do not introduce new requirements. If a revision to resolve conflicting or incorrect wording is required to support the interpretation, the committee will issue an intent interpretation in parallel with a revision to the Code.

(b) Upon request, the committee will render an interpretation of any requirement of the Code. An interpretation can be rendered only in response to a request submitted through the online Inquiry Submittal Form at http://go.asme.org/InterpretationRequest. Upon submitting the form, the inquirer will receive an automatic email confirming receipt.

(c) ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the information submitted, it is the opinion of the committee that the inquirer should seek assistance, the request will be returned with the recommendation that such assistance be obtained. Inquirers may track the status of their requests at http://go.asme.org/Interpretations.

(d) ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

(e) Interpretations are published in the ASME Interpretations Database at http://go.asme.org/Interpretations as they are issued.

Committee Meetings

The ASME BPVC committees regularly hold meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the applicable committee. Information on future committee meetings can be found at http://go.asme.org/BCW.

PREAMBLE

The rules of this Section of the Code cover minimum construction requirements for the design, fabrication, installation, and inspection of steam heating, hot water heating, and hot water supply boilers that are directly fired with oil, gas, electricity, coal, or other solid or liquid fuels, and for operation at or below the pressure and temperature limits set forth in this document. Similar rules for potable water heaters are also included.

For Section IV application, the boiler proper or other vessels terminate at the supply and return connections to the system or the supply and feedwater connections of a hot water supply boiler. These connections may be any of the following:

(a) the first circumferential joint for welding end connections

(b) the face of the first flange in bolted flanged connections

(c) the first threaded joint in that type of connection

Included within the scope of the boiler are pressure-retaining covers for inspection openings, such as manhole covers, handhold covers, and plugs; and headers required to connect individual coils, tubes, or cast sections within a boiler.

The rules are divided into four major Parts: Part HG, applying to all materials of construction except as provided for in Part HLW; Part HF, applying to assemblies fabricated of wrought material, except as provided for in Part HLW; Part HC, applying to cast iron assemblies; Part HA, applying to boilers constructed of cast aluminum; and Part HLW, applying to potable water heaters. Part HF is further subdivided into Subpart HW, containing rules for welded construction, and Subpart HB, containing rules for brazed construction.

The Parts and Subparts of this Section are divided into Articles. Each Article is given a number and a title, as for example, Part HG, Article 3, Design. Articles are divided into paragraphs that are given a three-digit number, the first of which corresponds to the Article number. Thus, under Article 3 of Part HG, paragraph HG-307 will be found. Paragraphs are further subdivided into subparagraphs. Major subdivisions of paragraphs are designated by three- or four-digit numbers followed by a decimal point and a digit or digits. Where necessary, further subdivisions are represented by letters and then by numbers in parentheses. Minor subdivisions of the paragraphs are also represented by letters. A reference to one of these paragraphs in the text of the Section includes all of the applicable rules in that paragraph. Thus, reference to HG-307 includes all the rules in HG-307.1 through HG-307.4.

This Section does not contain rules to cover all possible details of design and construction. Where complete details are not given, it is intended that the manufacturer, subject to the acceptance of the Authorized Inspector, shall provide details of design and construction that will be as safe as otherwise required by these rules.

When the strength of any part cannot be computed with a satisfactory assurance of safety, these rules provide procedures for establishing its maximum allowable working pressure.

SUMMARY OF CHANGES

Changes listed below are identified on the pages by a margin note, **(25)**, placed next to the affected area.

Page	*Location*	*Change*
xiv	List of Sections	Title of Section XI, Division 1 revised
xv	Foreword	Third, fourth, seventh, tenth, and eleventh paragraphs editorially revised
xviii	Personnel	Updated
4	HG-301.2	Title and subpara. (e) revised
23	HG-342.5	Deleted
30	HG-350.2	Equation (2) revised
33	Table HG-370	Units for "Size of Pipe Connection" revised
33	HG-370.2	(1) Subparagraph (b) revised (2) Subparagraphs (c) and (d) added
34	HG-402A	Subparagraph (i) revised
41	HG-511	Subparagraph (e) revised
42	HG-515.3	Subparagraph (b) revised and subpara. (b)(16) added
43	HG-515.4	Revised
43	HG-520	Revised in its entirety
44	HG-530.1	Subparagraphs (a)(4) and (c) revised
45	Figure HG-530.2	Note (2) revised
45	Figure HG-530.3	Note (1) revised
46	HG-530.2	(1) Spacing in second line of subparas. (g)(1) and (g)(3) corrected by errata (2) Paragraphs following subpara. (g)(4) revised
46	Figure HG-530.4	Revised
46	Figure HG-530.5	Revised
47	Figure HG-530.6	Revised
47	Figure HG-530.7	Revised
48	Figure HG-530.8	Revised
49	HG-532.2	Last sentence revised
49	HG-533.2	Revised in its entirety
49	HG-533.3	Revised
49	HG-533.6	Title and first sentence revised
50	HG-540.5	First paragraph revised
50	HG-540.7	Revised
53	HG-605	First paragraph revised
53	HG-606	Title and subpara. (a) revised
54	HG-613	First paragraph revised
54	HG-614	Subparagraph (a) revised
58	HG-705	Subparagraph (c) revised
66	HG-801	Revised in its entirety
67	HG-803.1	Subparagraph (d) revised
70	HF-203.1	Endnote 19 and subpara. (b) revised
71	HF-203.2	Last sentence revised
75	HW-401	First paragraph revised
77	HW-613	Revised
94	HW-820.8	Subparagraph (d)(2) revised
96	HW-910	Subparagraph (b) revised
96	HW-911	Subparagraphs (a) and (b) revised
97	HB-1001	Revised

Page	Location	Change
99	HB-1202.4	Subparagraph (a) revised
103	HB-1501	First sentence revised
103	HB-1502	Subparagraph (a) editorially revised
103	HB-1503	Subparagraph (a) revised
116	HC-501.1	Third paragraph revised
117	HC-502.11.3	Revised
117	HC-502.12	Revised
117	HC-502.12.1	Subparagraphs (b)(2) and (d) revised
120	HA-200	In subpara. (a), cross-reference revised
125	HA-501.1	Third paragraph revised
126	HA-502.11.3	Revised
126	HA-502.12	Revised
126	HA-502.12.1	Subparagraph (d) revised
134	HLW-203	Subparagraph (b) revised
134	HLW-204	Revised in its entirety
139	HLW-401.4	Subparagraph (c) added
150	HLW-451	Subparagraph (b)(4)(-b) revised
152	HLW-453	Revised
156	HLW-506	Added
157	HLW-600.3	(1) Subparagraphs (a) and (c) revised (2) Subparagraph (g) added
158	HLW-601	Revised in its entirety
158	HLW-602.1	(1) Subparagraphs (a)(4), (c), (e), (e)(3), and (f) revised (2) Former subpara. (d) revised and redesignated as subpara. (b), and former subparas. (b) and (c) redesignated
159	Figure HLW-602.2	Note (3) revised
161	HLW-701.1	HLW-701.1 First paragraph revised by errata
166	HLW-901	(1) Subparagraph (a)(3) deleted (2) Subparagraphs (a), (b)(2), (b)(3), (b)(5), and (b)(6) revised, and subpara. (b)(6) added
166	HLW-903	Subparagraph (d) revised
168	2-100	Updated
169	Table 2-100	Updated
170	Mandatory Appendix 3	Title revised
170	3-100	Revised in its entirety
170	3-101	Title and subparas. (a), (b), and (c) revised
170	3-102	Added
172	Mandatory Appendix 4	Revised in its entirety
176	Form H-1	“Certificate of Shop Inspection” and “Certificate of Field Assembly Inspection if Required” revised
178	Form H-2	“Certificate of Shop Inspection” and “Certificate of Field Assembly Inspection” revised
180	Form H-3	“Certificate of Shop Inspection” and “Certificate of Field Assembly Inspection” revised
182	Form H-4	Form H-4 Line 10 and “Certificate of Shop Inspection” revised
184	Form H-5	Line 10(b) revised
189	Table 4-2	Added
190	Form HC-1	Circled reference numbers added
191	Form HC-2	Circled reference numbers added
192	Form HC-3	Circled reference numbers added
193	Form HA-1	Circled reference numbers added
194	Form HA-2	Circled reference numbers added

Page	*Location*	*Change*
195	Form HA-3	Circled reference numbers added
196	Form HLW-6	(1) In line 9, "(rolled or welded)" corrected by errata to "(expanded or welded)" (2) "Certificate of Shop Inspection" revised
198	Form HLW-7	"Certificate of Shop Inspection" revised
200	Form HLW-8	"Proof Test Certificate" revised
219	E-100	Revised
224	F-100.1	Second paragraph revised
225	F-202.10.2.2	Revised
226	Nonmandatory Appendix H	Updated

CROSS-REFERENCING IN THE ASME BPVC

Paragraphs within the ASME BPVC may include subparagraph breakdowns, i.e., nested lists. The following is a guide to the designation and cross-referencing of subparagraph breakdowns:

(a) Hierarchy of Subparagraph Breakdowns

(1) First-level breakdowns are designated as (a), (b), (c), etc.

(2) Second-level breakdowns are designated as (1), (2), (3), etc.

(3) Third-level breakdowns are designated as (-a), (-b), (-c), etc.

(4) Fourth-level breakdowns are designated as (-1), (-2), (-3), etc.

(5) Fifth-level breakdowns are designated as (+a), (+b), (+c), etc.

(6) Sixth-level breakdowns are designated as (+1), (+2), etc.

(b) Cross-References to Subparagraph Breakdowns. Cross-references within an alphanumerically designated paragraph (e.g., PG-1, UIG-56.1, NCD-3223) do not include the alphanumerical designator of that paragraph. The cross-references to subparagraph breakdowns follow the hierarchy of the designators under which the breakdown appears. The following examples show the format:

(1) If X.1(c)(1)(-a) is referenced in X.1(c)(1), it will be referenced as (-a).

(2) If X.1(c)(1)(-a) is referenced in X.1(c)(2), it will be referenced as (1)(-a).

(3) If X.1(c)(1)(-a) is referenced in X.1(e)(1), it will be referenced as (c)(1)(-a).

(4) If X.1(c)(1)(-a) is referenced in X.2(c)(2), it will be referenced as X.1(c)(1)(-a).

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PART HG
GENERAL REQUIREMENTS FOR ALL MATERIALS OF CONSTRUCTION

ARTICLE 1
SCOPE AND SERVICE RESTRICTIONS

HG-100 SCOPE

(a) The rules of Part HG apply to steam heating boilers, hot water heating boilers, hot water supply boilers, and to appurtenances thereto. They shall be used in conjunction with the specific requirements in Part HF (boilers of wrought materials), Part HC (cast iron boilers), and Part HA (cast aluminum boilers), as applicable. The Foreword provides the basis for these rules. Part HG is not intended to apply to potable water heaters except as provided for in Part HLW. Boilers with economizers shall follow the rules of Mandatory Appendix 10.

(b) This Part contains mandatory requirements, specific prohibitions, and nonmandatory guidance for materials, designs, fabrication, examination, inspection, testing, certification, and overpressure protection. When detailed rules are not given in Section IV, the Manufacturer, subject to the acceptance of the Authorized Inspector, shall provide details of design that will be as safe as those provided by the rules of Section IV. This may be done by appropriate analytical methods, the appropriate use of rules from other design Codes or, as permitted in HG-500, by proof test.

(c) The Manufacturer shall establish the effective Code edition, addenda, and cases in accordance with Mandatory Appendix 9. Laws or regulations issued by a municipality, state, provincial, federal, or other enforcement or regulatory body having jurisdiction at the location of an installation, establish the mandatory applicability of these rules, in whole or in part.

HG-101 SERVICE RESTRICTIONS

HG-101.1 Service Restrictions. The rules of this Section are restricted to the following services:

(a) steam boilers for operation at pressures not exceeding 15 psi (100 kPa)

(b) hot water heating boilers and hot water supply boilers for operation at pressures not exceeding 160 psi (1 100 kPa)

(c) hot water heating boilers and hot water supply boilers for operation at temperatures not exceeding 250°F (120°C), at or near the boiler outlet, except that when some of the wrought materials permitted by Part HF are used, a lower temperature is specified

HG-101.2 Services in Excess of Those Covered by This Section. For services exceeding the limits specified in HG-101.1, the rules of Section I shall apply.

HG-102 UNITS

Either U.S. Customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this edition (e.g., materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection).

In general, it is expected that a single system of units shall be used for all aspects of design except where unfeasible or impractical. When components are manufactured at different locations where local customary units are different than those used for the general design, the local units may be used for the design and documentation of that component. Similarly, for proprietary components or those uniquely associated with a system of units different than that used for the general design, the alternate units may be used for the design and documentation of that component.

For any single equation, all variables shall be expressed in a single system of units. When separate equations are provided for U.S. Customary and SI units, those equations must be executed using variables in the units associated with the specific equation. Data expressed in other units shall be converted to U.S. Customary or SI units for use in these equations. The result obtained from execution of these equations may be converted to other units.

Production, measurement and test equipment, drawings, welding procedure specifications, welding procedure and performance qualifications, and other fabrication documents may be in U.S. Customary, SI, or local customary units in accordance with the fabricator's practice. When values shown in calculations and analysis, fabrication documents, or measurement and test equipment are in different units, any conversions necessary for verification of Code compliance and to ensure that dimensional consistency is maintained shall be in accordance with the following:

(a) Conversion factors shall be accurate to at least four significant figures.

(b) The results of conversions of units shall be expressed to a minimum of three significant figures.

Conversion of units, using the precision specified above shall be performed to assure that dimensional consistency is maintained. Conversion factors between U.S. Customary and SI units may be found in the Nonmandatory Appendix M, Guidance for the Use of U.S. Customary and SI Units in the ASME Boiler and Pressure Vessel Code. Whenever local customary units are used the Manufacturer shall provide the source of the conversion factors, which shall be subject to verification and acceptance by the Authorized Inspector.

Material that has been manufactured and certified to either the U.S. Customary or SI material specification (e.g., SA-516M) may be used regardless of the unit system used in design. Standard fittings (e.g., flanges, elbows, etc.) that have been certified to either U.S. Customary units or SI units may be used regardless of the unit system used in design.

All entries on a Manufacturer's Data Report and data for Code required nameplate marking shall be in units consistent with the fabrication drawings for the component using U.S. Customary, SI, or local customary units. It is acceptable to show alternate units parenthetically. Users of this Code are cautioned that the receiving Jurisdiction should be contacted to ensure the units are acceptable.

HG-103 TOLERANCES

Except as stated elsewhere in this section, Section IV does not fully address tolerances. When dimensions, sizes, or other parameters are not specified with tolerances, the values of these parameters are considered nominal, and allowable tolerances or local variances may be considered acceptable when based on engineering judgment and standard practices as determined by the designer.

ARTICLE 2
MATERIAL REQUIREMENTS

HG-200 GENERAL MATERIAL REQUIREMENTS

HG-200.1 Materials Subject to Pressure Stress. Material subject to stress due to pressure shall conform to one of the specifications given in Section II and shall be limited to those that are permitted in HF-200 for boilers of wrought materials and HC-200 for cast iron boilers.

HG-200.2 Internal Parts Subject to Deterioration. Materials shall not be used for internal parts that are liable to fail due to deterioration when subjected to saturated steam temperatures at or below the maximum allowable working pressure.

HG-200.3 Materials Not Found in Section II. Material not covered by specifications in Section II shall not be used unless authorization to use the material is granted by the Boiler and Pressure Vessel Committee on the basis of data submitted to the Committee in accordance with Section II, Part D, Mandatory Appendix 5.

HG-200.4 Materials Use Not Limited by Specification Title. The title or scope paragraph of a material specification in Section II with respect to product form or service shall not limit the use of a material, provided the material is suitable for the application and its use is permitted by the rules of this Section.

HG-200.5 Materials Use Not Limited by Method of Production. Materials covered by specifications in Section II are not restricted as to the method of production unless so stated in the Specification, and as long as the product complies with the requirements of the Specification.

HG-200.6 Materials With Thicknesses Exceeding Specification Limits. Materials having thicknesses outside of the limits given in the title or scope clause of a specification in Section II may be used in construction, provided they comply with the other requirements of the Specification and with all thickness requirements of this Code.

HG-200.7 Nonpressure Part Materials. Material for nonpressure parts, such as skirts, supports, baffles, lugs, clips, and extended heat-transfer surfaces, need not conform to the specifications for the material to which they are attached or to a material specification permitted in HF-200 or HC-200; but, if welded, they shall be of weldable quality. The allowable stress value shall not exceed 80% of the maximum allowable stress permitted for similar material in Section II, Part D, Table 6A or Table 6B. Satisfactory performance of a specimen in such service shall not make the material acceptable for use in pressure parts of a vessel.

HG-201 SPECIFIC MATERIAL REQUIREMENTS

Specific material requirements for assemblies constructed of wrought materials are given in Part HF, Article 2 and for assemblies constructed of cast iron in Part HC, Article 2.

ARTICLE 3
DESIGN

HG-300 DESIGN PRESSURE

(a) The design pressure is the pressure used in the formulas of this Article, in conjunction with the allowable stress values, design rules, and dimensions specified for determining the minimum required thicknesses for the parts of a boiler. The design pressure for a heating boiler shall be at least 30 psi (200 kPa).

(b) The term maximum allowable working pressure refers to gage pressure, or the pressure in excess of the atmospheric pressure in the boiler. The maximum allowable working pressure, as marked on the boiler per HG-530, must be less than or equal to the design pressure for any of its parts.

(c) No boiler shall be operated at a pressure higher than the maximum allowable working pressure except when the pressure relief valves are discharging, at which time the maximum allowable working pressure shall not be exceeded by more than the amount specified in HG-402A.1 and HG-402A.2.

HG-300.1 Vacuum Boilers. Rules for factory sealed boilers to be operated only under vacuum conditions are given in Mandatory Appendix 5.

HG-301 CYLINDRICAL PARTS UNDER INTERNAL PRESSURE

HG-301.1 General. The required thickness and the design pressure of cylindrical shells, tubes, pipe, and headers shall be determined in accordance with the following formulas:

$$t = \frac{PR}{SE - 0.6P}$$

$$P = \frac{SEt}{R + 0.6t}$$

where

E = efficiency of longitudinal joint or of ligament between tube holes, whichever is the lesser. For welded joints, use the efficiency specified in HW-702. For seamless shells, use $E = 1$. Welded pipe or tubing shall be treated in the same manner as seamless, but with allowable tensile strength taken from the welded product values of the stress tables in Section II, Part D.

P = design pressure [but not less than 30 psi (200 kPa)]

R = inside radius of cylinder

S = maximum allowable stress value from Section II, Part D, Table 6A or Table 6B

t = required wall thickness

HG-301.2 Tubes and Pipes (25)

(a) The wall thickness of tubes and pipes subject to internal pressure shall be determined in accordance with the formulas in HG-301.1.

(b) The wall thickness of tubes and pipes subject to external pressure shall be determined by the procedures outlined in HG-312.3.

(c) In no case shall a tube or a pipe used as a tube have a wall thickness less than 0.02 in. (0.5 mm).

(d) Tubes installed by expanding shall have an additional 0.04 in. (1 mm) of wall thickness added to the minimum required thickness as an allowance for expanding and structural stability.

(e) The design temperature of tubes and pipes shall be the mean metal temperature as determined by the boiler Manufacturer.

(f) For austenitic stainless steel materials, the water temperature shall not exceed 210°F (99°C).

(g) Welding or brazing shall be qualified in accordance with Section IX.

HG-305 FORMED HEADS, PRESSURE ON CONCAVE SIDE

HG-305.1 General. The required thickness at the thinnest point after forming of ellipsoidal, torispherical, and hemispherical heads under pressure on the concave side (plus heads) shall be computed by the appropriate formulas in this paragraph.

(a) Notation. The symbols used in this paragraph are defined as follows:

D = inside diameter of the head skirt; or inside length of the major axis of an ellipsoidal head; or inside diameter of a cone head at the point under consideration, measured perpendicular to the longitudinal axis

E = lowest efficiency of any joint in the head. For welded joints, use the efficiency specified in HW-702. For seamless heads, use $E = 1$, except for hemispherical heads furnished without a skirt, in which case use the efficiency of the head-to-shell joint.
L = inside spherical or crown radius
P = design pressure [but not less than 30 psi (200 kPa)]
S = maximum allowable stress value as given in Section II, Part D, Table 6A or Table 6B
t = required wall thickness after forming

HG-305.2 Ellipsoidal Heads. The required thickness and the design pressure of a dished head of semiellipsoidal form, in which half the minor axis (inside depth of the head minus the skirt) equals one-fourth of the inside diameter of the head skirt, shall be calculated by the following formulas:

$$t = \frac{PD}{2SE - 0.2P}$$

or

$$P = \frac{2SEt}{D + 0.2t}$$

HG-305.3 Torispherical Heads. The required thickness and the design pressure of a torispherical head shall be calculated by the following formulas (see HG-305.6):

$$t = \frac{0.885PL}{SE - 0.1P}$$

or

$$P = \frac{SEt}{0.885L + 0.1t}$$

HG-305.4 Hemispherical Heads. The required thickness and the design pressure of a hemispherical head in which P does not exceed $0.665SE$ shall be calculated by the following formulas:

$$t = \frac{PL}{2SE - 0.2P}$$

or

$$P = \frac{2SEt}{L + 0.2t}$$

HG-305.5 Formed Heads With Stays. A formed head of a lesser thickness than that required by the rules of this paragraph may be used provided it is stayed as a flat surface according to the rules of HG-340 for stayed flat plates, no allowance being made in such staying for the holding power due to the curvature of the head unless all the following conditions are met:

(a) The head is at least two-thirds as thick as required by the rules of this paragraph for an unstayed head.

(b) The head is at least $\frac{7}{8}$ in. (22 mm) thick.

(c) The stays are through-stays attached to the head by outside and inside nuts or welding.

(d) The design pressure on the head is taken as that calculated for an unstayed formed head plus the pressure calculated for the stays by the equation for stayed surfaces in HG-340 using a value of $C = 1.63$.

HG-305.6 Inside Crown Radius of Unstayed Heads. The inside crown radius to which an unstayed formed head is dished shall be not greater than the outside diameter of the skirt of the head. The inside knuckle radius of a torispherical head shall be not less than 6% of the outside diameter of the skirt of the head but in no case less than three times the head thickness.

HG-305.7 Heads Built up of Several Shapes. A head for a cylindrical shell may be built up of several head shapes, the thicknesses of which satisfy the requirements of the appropriate formulas above, provided that adjoining shapes are so formed that they have a common tangent transverse to the joint.

HG-305.8 Length of Skirts. The required length of skirt on heads concave and convex to pressure shall comply with HW-715.

HG-305.9 Permissible Diameter of Flat Spots on Formed Heads. If a torispherical, ellipsoidal, or hemispherical head is formed with a flattened spot or surface, the diameter of the flat spot shall not exceed that permitted for flat heads as given by the equation in HG-307, using $C = 0.20$.

HG-306 FORMED HEADS, PRESSURE ON CONVEX SIDE

HG-306.1 Unstayed dished heads with the pressure on the convex side shall have a design pressure equal to 60% of that for heads of the same dimensions having the pressure on the concave side (see HG-305).

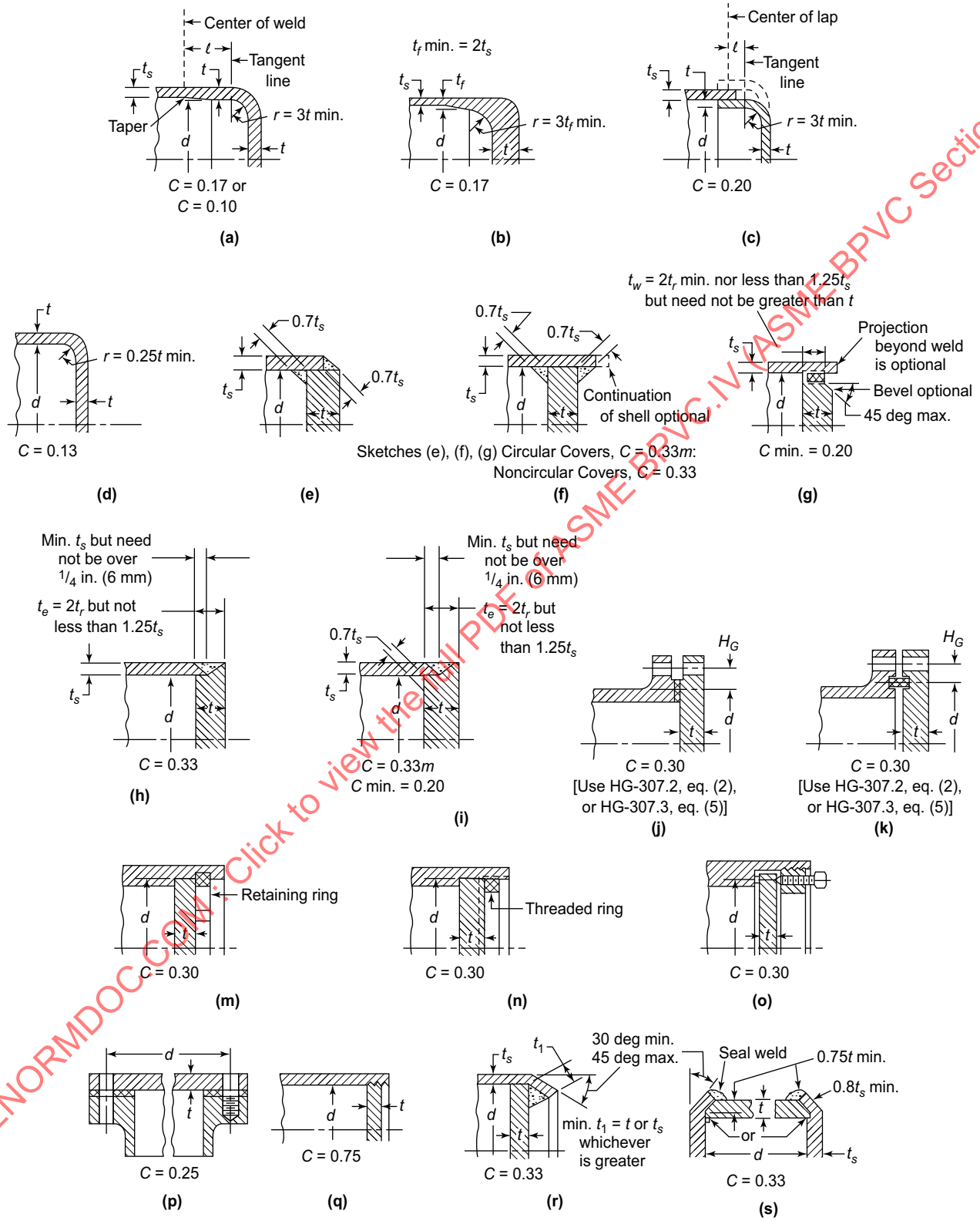
HG-307 FLAT HEADS

HG-307.1 General. The minimum thickness of unstayed heads, cover plates, and blind flanges shall conform to the requirements given in this paragraph. These requirements apply to both circular and noncircular heads and covers. In addition, flat heads or covers made of cast iron shall be subjected to the proof test provisions of HG-500. Some acceptable types of flat heads and covers are shown in Figure HG-307.

The symbols used in this paragraph and Figure HG-307 are defined as follows:

C = a factor depending upon the method of attachment of the head, shell, pipe, or header dimensions, and other items as listed in HG-307.4 below, dimensionless. The factors for welded covers also

Figure HG-307
Some Acceptable Types of Unstayed Flat Heads and Covers



GENERAL NOTE: These illustrations are diagrammatic only; other designs that meet the requirements of HG-307 will be acceptable.

include a factor of 0.667 that effectively increases the allowable stress for such construction to 1.5S.

D = long span of noncircular heads or covers measured perpendicular to short span

d = diameter, or short span, measured as indicated in Figure HG-307

H_G = gasket moment arm, equal to the radial distance from the center line of the bolts to the line of the gasket reaction, as shown in Figure HG-307, sketches (j) and (k)

L = perimeter of noncircular bolted head measured along the centers of the bolt holes

l = length of flange or flanged heads, measured from the tangent line of knuckle, as indicated in Figure HG-307, sketches (a) and (c)

m = the ratio t_r/t_s, dimensionless

P = design pressure

r = inside corner radius on the head formed by flanging or forging

S = maximum allowable stress value using values given in Section II, Part D, Table 6A or Table 6B

t = minimum required thickness of flat head or cover

t_1 = throat dimension of the closure weld, as indicated in Figure HG-307, sketch (r)

t_e = minimum distance from beveled end of drum, pipe, or header, before welding, to outer face of head, as indicated in Figure HG-307, sketch (i)

t_f = actual thickness of the flange on a forged head, at the large end, as indicated in Figure HG-307, sketch (b)

t_h = actual thickness of flat head or cover

t_r = required thickness of seamless shell, pipe, or header, for pressure

t_s = actual thickness of shell, pipe, or header

t_w = thickness through the weld joining the edge of a head to the inside of a drum, pipe, or header, as indicated in Figure HG-307, sketch (g)

W = total bolt load as further defined in HG-307.2

Z = a factor for noncircular heads and covers that depends on the ratio of short span to long span, as given in HG-307.3 below, dimensionless

HG-307.2 Thickness of Circular, Flat, Unstayed Heads, Covers, and Blind Flanges. The thickness of flat unstayed heads, covers, and blind flanges shall conform to one of the following requirements:

(a) Circular blind flanges of ferrous materials conforming to ASME B16.5 shall be acceptable for the diameters and pressure–temperature ratings in Tables 2 through 8 of that Standard when of the types shown in Figure HG-307, sketches (j) and (k).

(b) The minimum required thickness of flat unstayed circular heads, covers, and blind flanges shall be calculated by the following equation:

$$t = d\sqrt{CP/S} \tag{1}$$

except when the head, cover, or blind flange is attached by bolts causing an edge moment [Figure HG-307, sketches (j) and (k)], in which case the thickness shall be calculated by

$$t = d\sqrt{CP/S + 1.9WH_G/Sd^3} \tag{2}$$

When using eq. (2), the thickness t shall be calculated for both operating conditions and gasket seating, and the greater of the two values shall be used. For operating conditions, the value of P shall be the design pressure, the value of S at design temperature shall be used, and W shall be the sum of the bolt loads required to resist the end pressure load and to maintain tightness of the gasket. For gasket seating, P equals zero, the value of S at atmospheric temperature shall be used, and W shall be the average of the required bolt load and the load available from the bolt area actually used.

HG-307.3 Thickness of Noncircular, Flat, Unstayed Heads, Covers, and Blind Flanges.

(a) Flat unstayed heads, covers, or blind flanges may be square, rectangular, elliptical, obround, segmental, or otherwise noncircular. Their required thickness shall be calculated by the following equation:

$$t = d\sqrt{ZCP/S} \tag{3}$$

where

$$Z = 3.4 - \frac{2.4d}{D} \tag{4}$$

with the limitation that Z need not be greater than 2.5.

(b) Equation (3) of (a) does not apply to noncircular heads, covers, or blind flanges attached by bolts causing a bolt edge moment [Figure HG-307, sketches (j) and (k)]. For noncircular heads of this type, the required thickness shall be calculated by the following equation:

$$t = d\sqrt{ZCP/S + 6WH_G/SLd^2} \tag{5}$$

When using eq. (5), the thickness t shall be calculated in the same way as specified above for HG-307.2(b), eq. (2).

HG-307.4 Values of C for Use in Equations in HG-307.2 and HG-307.3. For the types of construction shown in Figure HG-307, the values of C to be used in HG-307.2(b), eqs. (1) and (2); HG-307.3(a), eq. (3); and HG-307.3(b), eq. (5) are as follows:

(a) Figure HG-307, sketch (a): C = 0.17 for flanged circular and noncircular heads forged integral with or butt welded to the shell, pipe, or header, with an inside corner radius not less than three times the required head thickness, with no special requirement with regard to length of flange, and where the welding meets all the